

REMARKS

Applicants respectfully request reconsideration and withdrawal of the outstanding Office Action rejections based on the foregoing amendments and following remarks. Claim 14 has been amended only to clarify the claims based on the Examiner's questions about the "lateral direction" and also to put the claims in better condition for allowance. Support for the amendments can be found on page 1, 2nd paragraph and in the paragraph bridging pages 5 and 6 of the specification. Applicants request that the amendments be entered. No new matter has been added.

Response to Objections to the Drawings

The Examiner has objected to the drawings because the Examiner contends that Figure 4 does not show the appropriate band structure of the quantum dots. Applicants submit that the enclosed replacement figure indicates the direction of the stacking direction and shows the conduction band edge of the nanostructures. Moreover, Figure 4, as amended, removes the physical nanostructures from the band diagram. Accordingly, Applicant respectfully request reconsideration and withdrawal of this objection.

Response to Rejections under 35 U.S.C. §112

Claims 14-26 have been rejected under 35 U.S.C. §112, second paragraph, as being indefinite. The Examiner asserts that the lateral direction is unclear. Applicants submit that claim 14 has been amended to clarify the meaning of lateral direction.

Applicants submit that there is clear disclosure on page 1, paragraph 2 of the specification that the lateral direction is perpendicular to the stacking direction of the layers. Thus, Applicants have incorporated this language into the rejected claims to clarify the meaning of "lateral". Accordingly, Applicant respectfully requests reconsideration and withdrawal the rejections under 35 U.S.C. 112, second paragraph.

Response to Rejections under 35 U.S.C. §102

Claims 14-25 were rejected under 35 U.S.C. §102(b) as being allegedly anticipated by Holonyak (US Published Patent Application No. 2003/0059998). The Examiner contends that Holonyak discloses each and every element of present claims 14-25. More specifically, the Examiner contends that Holonyak discloses a quantum well structure for the absorption or emission of photons comprising a quantum well layer arranged between two barrier layers, wherein at least one of the barrier layers comprises nanostructures which compensate or modulate a lateral homogeneity of the barrier layer which is present without the nanostructures wherein the quantum well layer is the absorption or emission layer.

Holonyak discloses quantum dots that are separated from a quantum well by a barrier layer having a thickness of between 5 and 100 Angstroms (see paragraph [0013]). Paragraph [0007] of Holonyak states "Also, should the QDs not collect injected electron-hole pairs efficiently (a distinct possibility), the thin auxiliary QW layer (or, if necessary or desirable, multiple QW layers) will collect the injected carriers and feed them via resonant tunneling into the quantum dots to then scatter the carriers down to

the lower energy dot states for recombination (for photon generation and laser operation)." Thus, Applicants submit that, in Holonyak, the purpose of the quantum dots is to use their high density of states to capture electrons and holes to feed into the quantum well, coupled to the quantum dot layer via tunnelling through the barrier. Therefore, the quantum dots of Holonyak, which are the lowest bandgap part of the structure (see paragraph [0008] of Holonyak), for example being made of InAs, the lowest bandgap material in the exemplary structures, are the part of the structure that collects the carriers.

Conversely, in the presently claimed structure, the carriers do not collect in the nanostructures; rather, the carriers tunnel through the barrier layer, which comprises nanostructures arranged such that said nanostructures cancel or modulate a homogeneity of said quantum well layer extending in at least one lateral direction in the absence of said nanostructures, without substantially influencing energy values in said quantum well layers. Thus, while in the structure disclosed by Holonyak, the carriers are fed from the quantum wells down to the lower energy dot states, in the presently claimed structure, as amended, the nanostructures do not affect the energy values of the carriers in the quantum well layers.

According to the enclosed declaration signed by one of the inventors, Dr. William Ted Masselink, the presently claimed structure is configured so that carriers transition from a high energy state to a low energy state in the quantum wells and the nanostructures are configured so that their bandgap is larger than the bandgap of the quantum well so that the nanostructures do not substantially influence energy values in said quantum well layers. Dr. Masselink states that rather than being the low energy

collection sink for carriers as in Holonyak, in the present invention the quantum dots are configured so that they cancel or modulate a homogeneity of said quantum well layer extending in at least one lateral direction in the absence of said nanostructures without substantially influencing energy values in said quantum well layers. Thus, by keeping the carriers in the quantum wells, rather than in the quantum dots as in Holonyak, the present structure allows better control of the carriers' energy.

Further, Dr. Masselink states that at the time of filing, one of skill in the art would know that if nanostructures, e.g. quantum dots, were present in a quantum well structure, and the nanostructures did not substantially influence the energy levels of the electrons in the quantum wells, then those nanostructures would have larger bandgap than the band gap of the quantum wells. Thus, because the presently claimed structure requires that the nanostructures cancel or modulate a homogeneity of said quantum well layer extending in at least one lateral direction in the absence of the nanostructures, without substantially influencing energy values in the quantum well layers, the claimed structure requires nanostructures with bandgaps that are higher than those of the quantum wells.

Thus, contrary to the structure of Holonyak, the nanostructures required by present claim 14 are part of the barrier layer and are configured to break the translational symmetry, thus allowing photons with electric-field vector perpendicular to the surface to couple to intersubband transitions. These nanostructures do not substantially influence energy values in said quantum well layers and do not act as electron sinks.

This distinction is further supported by the fact that the nanostructures in the presently claimed structure do not cancel or modulate the homogeneity of the quantum well structure itself (see page 12, lines 25-28). This is because the nanostructures do not substantially influence the energy values of the carriers in the quantum well layers. However, in Holonyak, because the quantum dots collect the carriers, their presence will inherently influence the homogeneity of the structure as a whole depending on the position of the quantum dots.

For at least the aforementioned reasons, Applicant respectfully submits that Holonyak does not and can not anticipate each and every element of present claim 14. Moreover, since claims 15-25 are dependent upon claim 14, either directly or indirectly, Applicant respectfully submits that Holonyak does not and can not anticipate each and every element of present claims 15-25. Accordingly, Applicant respectfully requests reconsideration and withdrawal of the outstanding 35 U.S.C. 102(b) rejection.

Response to Rejections under 35 U.S.C. §103

Claim 26 stands rejected under 35 U.S.C. 103(a) as being allegedly unpatentable over Faist (*IEEE J. of Quantum Electronics*, v. 38, No. 6, June 2002, pages 533-546) in view of Holonyak (US Published Patent Application No. 2003/0059998). The Examiner contends that Faist teaches a quantum well cascade laser, but does not teach the quantum well structure of present claim 14. The Examiner relies on Holonyak for a disclosure of using quantum dots as a source of carriers. The Applicant respectfully disagrees with the Examiner's contention and submit that the Examiner has not established a prima facie case of obviousness for at least the following reasons.

As outlined above, Holonyak does not and can not anticipate each and every element of present claim 14 because Holonyak does not disclose nanostructures, or quantum dots, that comprise at least a portion of a barrier layer. Therefore, the combination of Faist and Holonyak would lead to a quantum cascade laser (from Faist) that comprises a quantum well structure having low bandgap quantum dots to collect the electrons. Furthermore, there is no teaching or disclosure in either of Faist or Holonyak for a quantum well structure configured essentially in an opposite manner than that which is disclosed in the disclosure Holonyak. Thus, the combination of Holonyak and Faist would not suggest to one of ordinary skill in the art how to arrive at a quantum cascade laser having a quantum well structure as is presently claimed. Thus, Applicant submits that the disclosure of Holonyak does not cure the noted deficiencies of Faist or vice versa. Accordingly, Applicant respectfully requests reconsideration and withdrawal of the outstanding 35 U.S.C. 103(a) rejection.

Conclusions

In view of the foregoing amendments and remarks, Applicants respectfully request withdrawal of the outstanding Office Action rejections. Early and favorable action is awaited. The Director is authorized to charge any fees or overpayment to Deposit Account No. 02-2135.

Respectfully submitted,

By 

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Enclosure: Declaration of Dr. Masselink
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